

SYSTEMS AND METHODS FOR ESTABLISHING RELIABLE WIRELESS LINKS

BACKGROUND

[0001] This relates to electronic devices, and more particularly, to electronic devices with wireless circuitry.

[0002] Electronic devices are often provided with wireless communications capabilities. Because wireless circuitry such as antennas have the potential to interfere with each other and with other components in a wireless device, care must be taken when incorporating antennas into an electronic device to ensure that the antennas and other wireless circuitry are able to exhibit satisfactory performance over a wide range of operating frequencies.

[0003] In some applications, it is desirable to incorporate wireless circuitry that allows for relatively high rates of data transfer. However, operations of the wireless circuitry at relatively high frequencies, such as at frequencies of about 10-300 GHz, that allow for high data rate data transfer can raise significant challenges. As an example, signal polarization misalignment between communicating devices and directional misalignment between communicating devices often degrade wireless communication links between the communicating devices.

[0004] It would therefore be desirable to be able to provide improved wireless circuitry and interfacing circuitry for electronic devices.

SUMMARY

[0005] An electronic device, such as a wristwatch or a wireless power receiving device, may have front and rear faces. A display having a display cover glass may be disposed at the front face and a rear housing wall (e.g., rear housing member) may be disposed at rear face. One or more antenna resonating elements for an antenna may overlap the rear housing wall and that is operable to transmit radio-frequency signals through the rear housing wall. The one or more antenna resonating elements may for an antenna array for the electronic device. Radio-frequency transceiver circuitry (e.g., near-field communications circuitry) may be coupled to the one or more antenna resonating elements and may be operable to use the one or more antenna resonating elements to transmit radio-frequency signals above 10 GHz through the rear housing wall. If desired, the radio-frequency transceiver circuitry may be operable use only a subset of the antenna resonating elements in the antenna array and/or may be operable to use a pair of the antenna resonating elements in the antenna resonating elements in the antenna array at a time.

[0006] As an example, the one or more antenna resonating elements may be formed at a substrate in a backside circuitry module (e.g., a sensor module). The radio-frequency transceiver circuitry may be mounted to the substrate. As another example, the one or more antenna resonating elements may be formed at a printed circuit substrate to which the radio-frequency transceiver circuitry and control circuitry that controls an operation of the radio-frequency transceiver circuitry are mounted. As yet another example, an additional antenna resonating element for an additional antenna may overlap the rear housing wall and may be operable to transmit additional radio-frequency signals through the rear housing wall. The one or more antenna resonating elements

may be aligned with one or more corresponding antenna apertures defined at least in part by the additional antenna resonating element.

[0007] If desired, the antenna resonating elements in the antenna array may overlap the rear housing wall along in a circumferential path about a central axis of the wristwatch. As an example, the rear housing wall has a protruding portion and the circumferential path may overlap the protruding portion. As another example, the rear housing wall may have a planar portion and the circumferential path may overlap the protruding portion.

[0008] In some embodiments, alignment structures may be disposed at the rear housing wall and may be configured to apply a force through the rear housing wall. The alignment structures may include first and second magnetic structures that apply magnetic forces through the rear housing wall. The first and second magnetic structures may be configured to bias the rear housing wall to equipment external to the electronic device (e.g., a wireless power transmitting device) and to align the antenna resonating element to the external equipment. The attachment structures may have first and second portions (e.g., the first and second magnetic structures), and the sensor module and coil structures are interposed between the first and second portions of the attachment structures.

[0009] The electronic device may wirelessly communicate with wireless power transmitting equipment. The wireless power transmitting equipment may include a housing, a coil structure, wireless power transmitting circuitry coupled to the coil structures and configured to use the coil structure to convey wireless power signals through a portion of the housing. The wireless power transmitting equipment may also include a plurality of antenna elements for an antenna array useable by radio-frequency transceiver circuitry to convey radio-frequency signals above 10 GHz through the portion of the housing.

[0010] As an example, the antenna array may be operable to sequentially use respective antenna elements in pairs of antenna elements in the plurality of antenna elements at a time to receive additional radio-frequency signals. Control circuitry may be configured to receive wireless performance information based on the additional radio-frequency signals received from the respective antenna elements in the pairs of antenna elements. The control circuitry may be operable to select one or more antenna elements in the plurality of antenna elements for conveying the radio-frequency signals based on the received wireless performance information.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a perspective view of an illustrative electronic device with wireless circuitry in accordance with some embodiments.

[0012] FIG. 2 is a schematic diagram of an illustrative electronic device with wireless circuitry in accordance with some embodiments.

[0013] FIG. 3 is a diagram of illustrative wireless circuitry in an electronic device in accordance with some embodiments.

[0014] FIG. 4 is a cross-sectional side view of an illustrative electronic device having antenna elements overlapping a rear housing wall in accordance with some embodiments.

[0015] FIG. 5 is a diagram of an illustrative dipole antenna element in accordance with some embodiments.